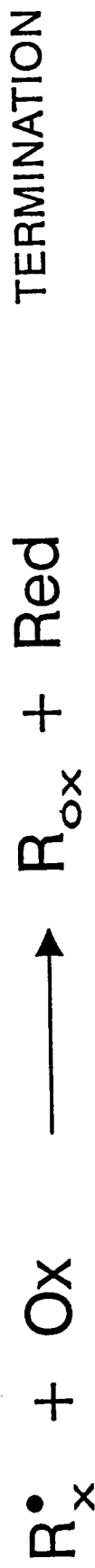

HOMOLYTIC OXIDATION OF CARBONYL COMPOUNDS BY METAL SALTS

**Synthetic Applications of the Intramolecular Homolytic
Aromatic Substitution**

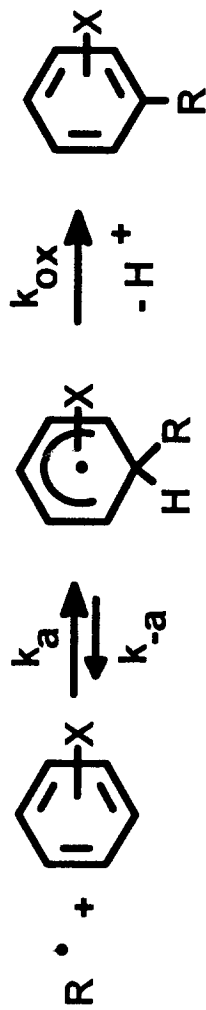
A. Citterio
Dipartimento di Chimica
Politecnico di Milano

HOMOLYTIC STOICHIOMETRIC OXIDATION

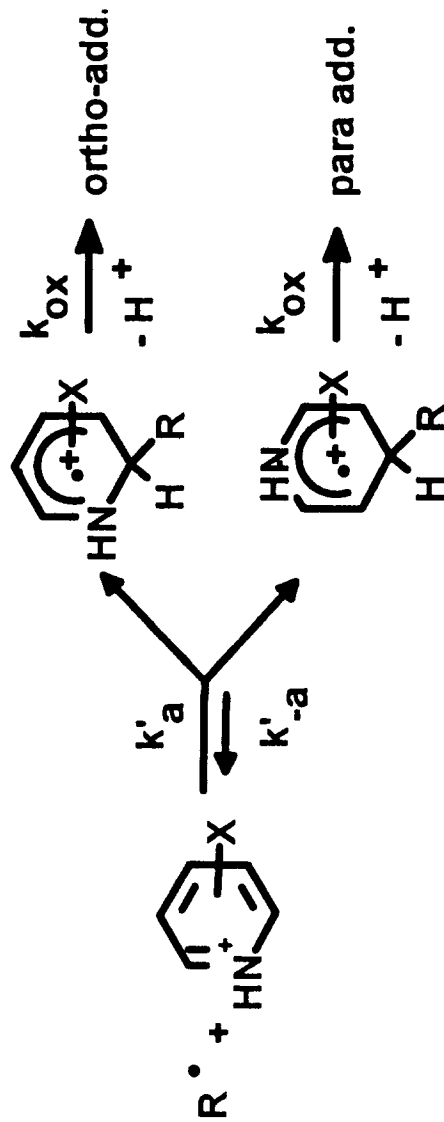


Electrochemical reoxidation

HOMOLYTIC AROMATIC SUBSTITUTION



$k_a (25^\circ\text{C}) = 1 - 10^2 \text{ M}^{-1}\text{s}^{-1}$
 (R = n-Hexenyl radical)

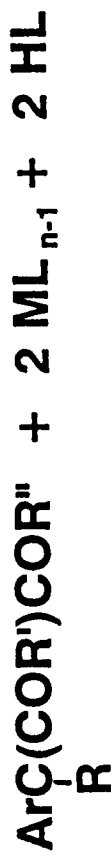


$k'_a (25^\circ\text{C}) = 10^3 - 10^6 \text{ M}^{-1}\text{s}^{-1}$

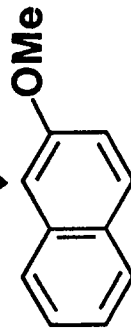
$k'_a (25^\circ\text{C}) = 10^2 - 10^4 \text{ s}^{-1}$

F. Minisci, A. Citterio, *Adv. Free Rad. Chem.*, Vol. VI, 65 (1980)

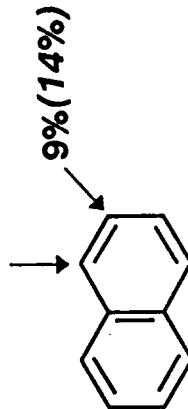
AROMATIC SUBSTITUTION BY ALPHA-DICARBONYLALKYL RADICALS



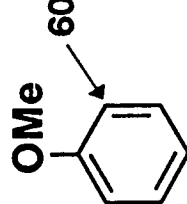
93% (88%)



91% (86%)

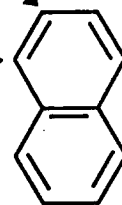


60% (67%)

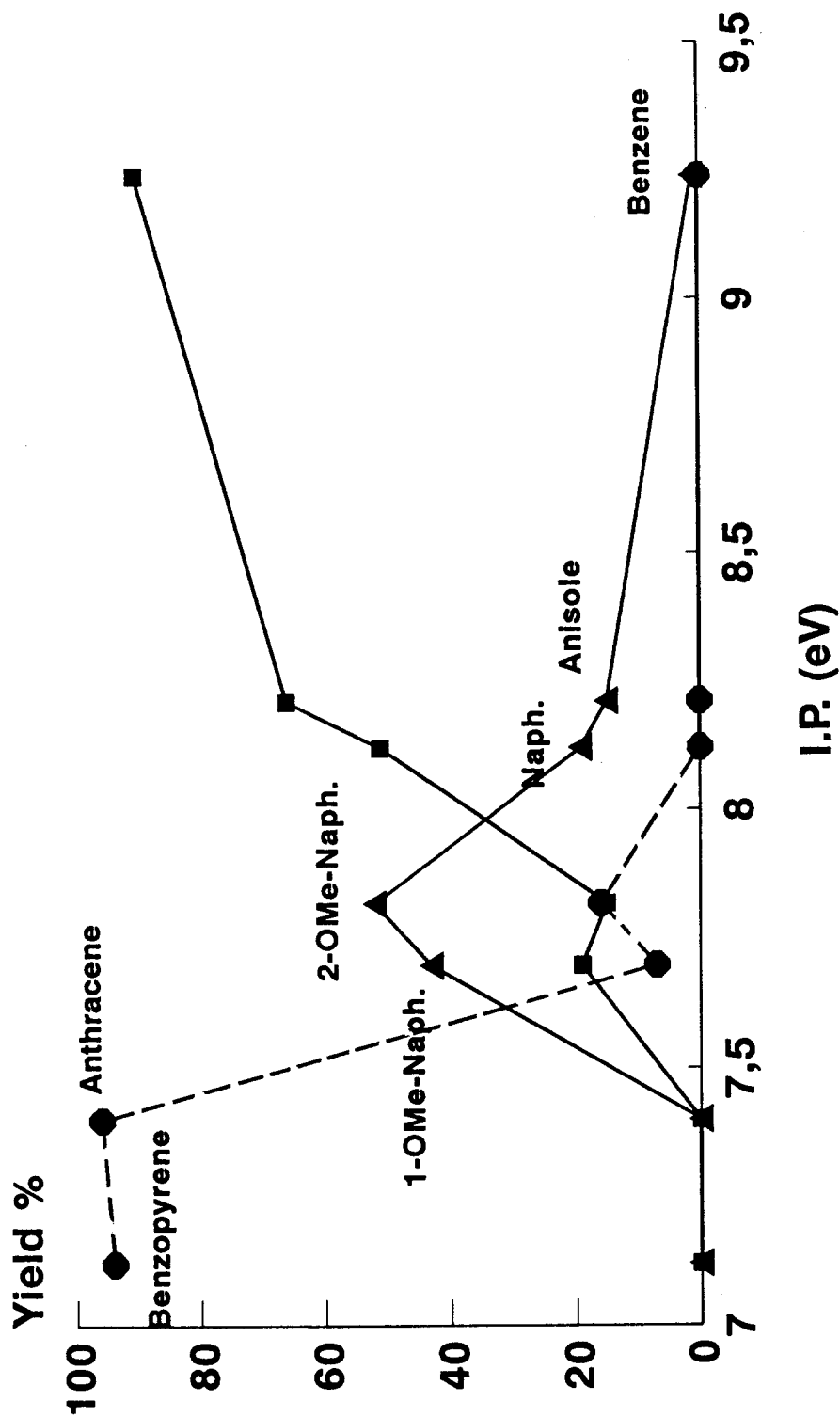


40% (30%)

9% (14%)

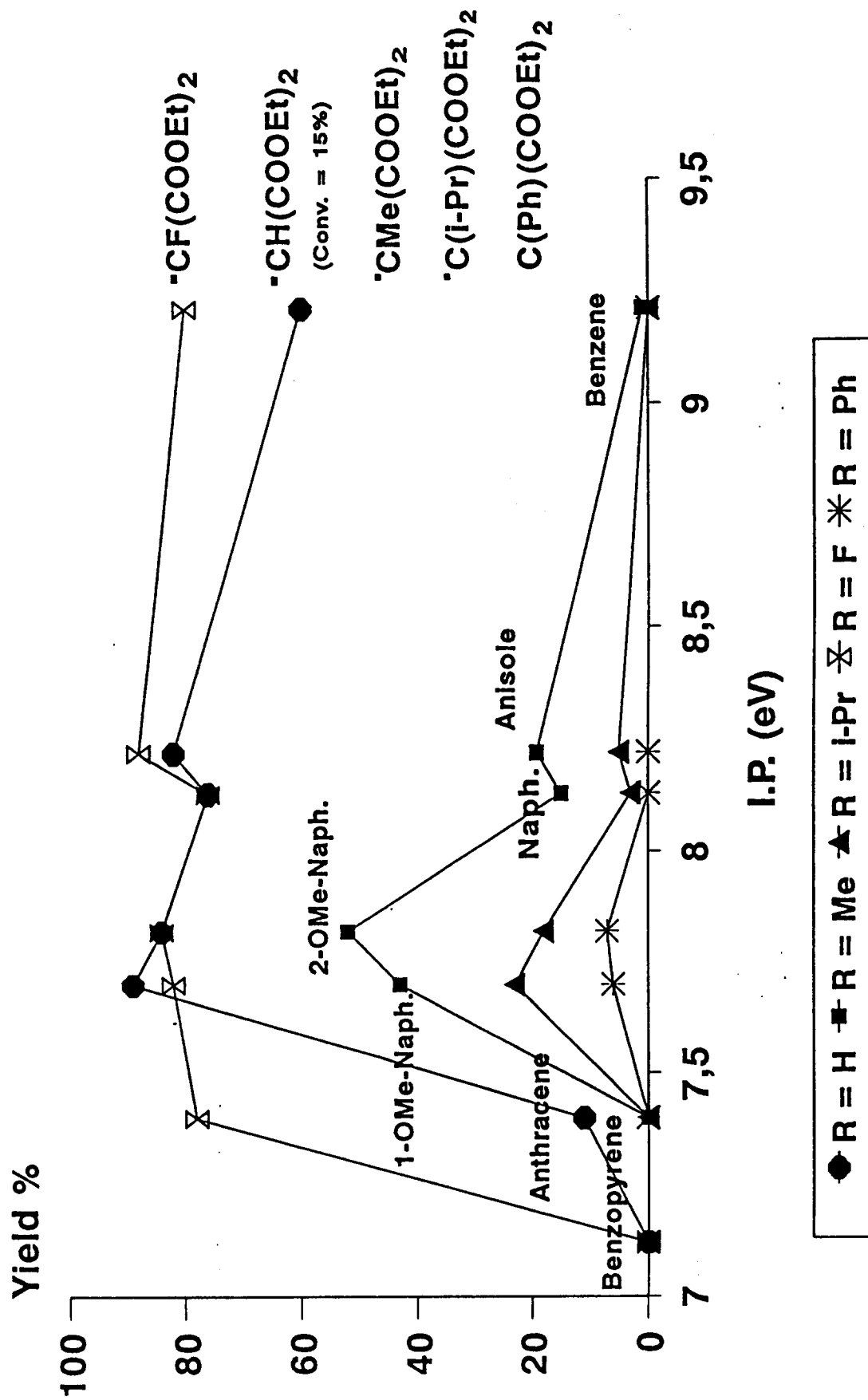


Dependence of Product Distribution on I.P. of Arenes in the Mn(III)Acetate Oxidation of Diethyl Methylmalonate in the Presence of Arenes (AcOH, 70°C, c = 0.2 M)

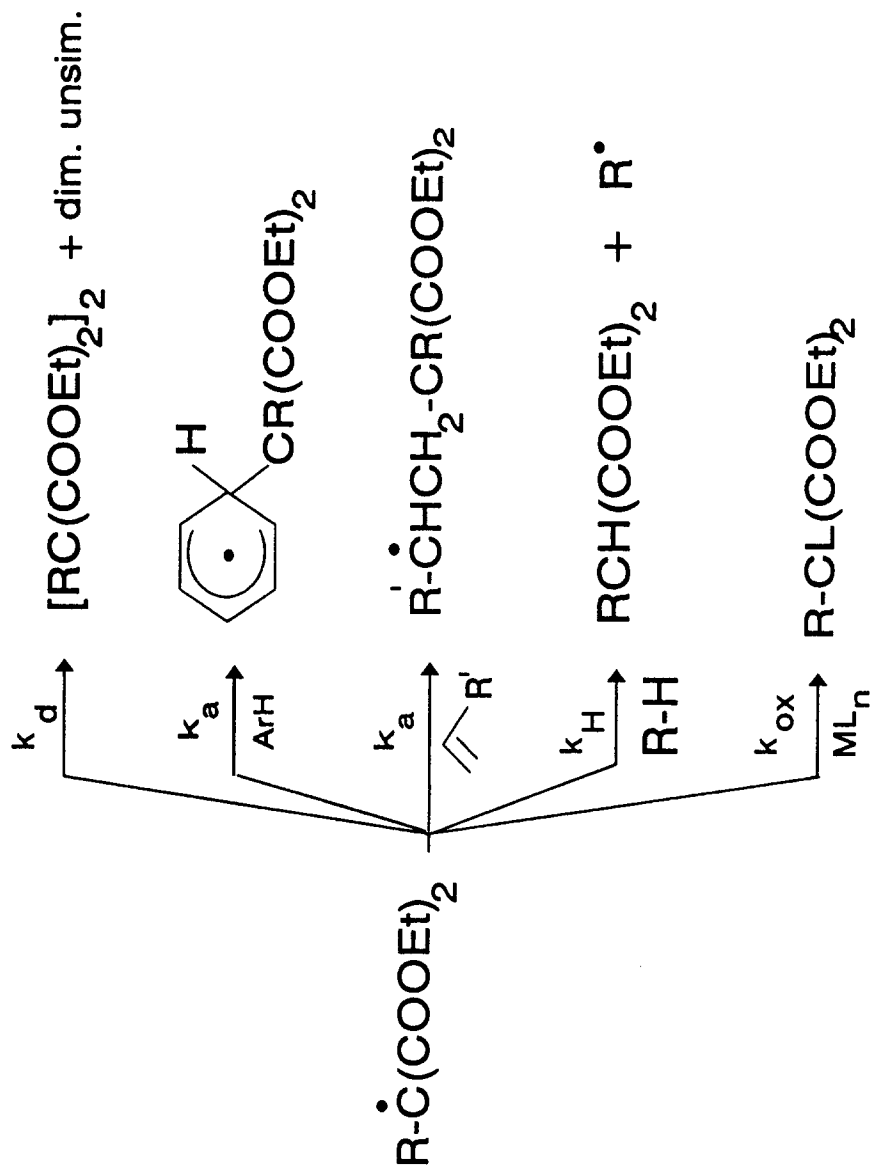


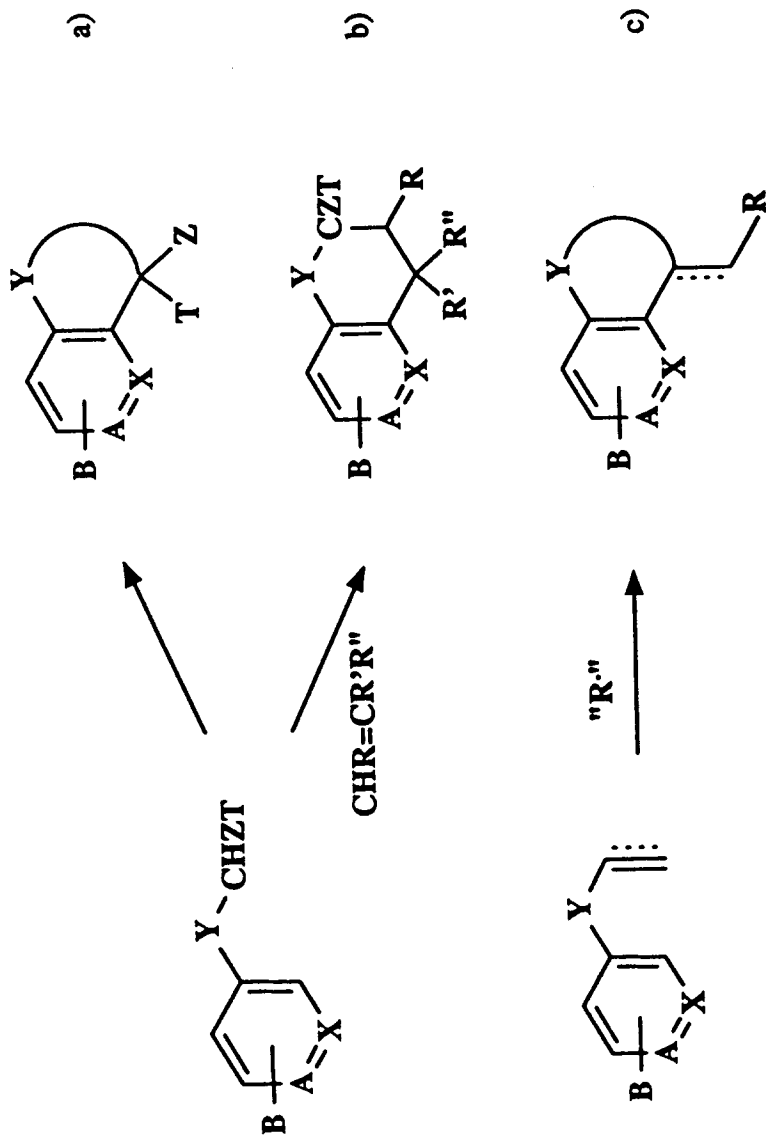
● Acetoxylation ▲ Malonylation ■ Oxidat. + Dimer.

Aromatic Substitution in the Mn(III) Acetate Oxidation of Diethyl Alfa-Substituted Malonates in the Presence of Aromatics.

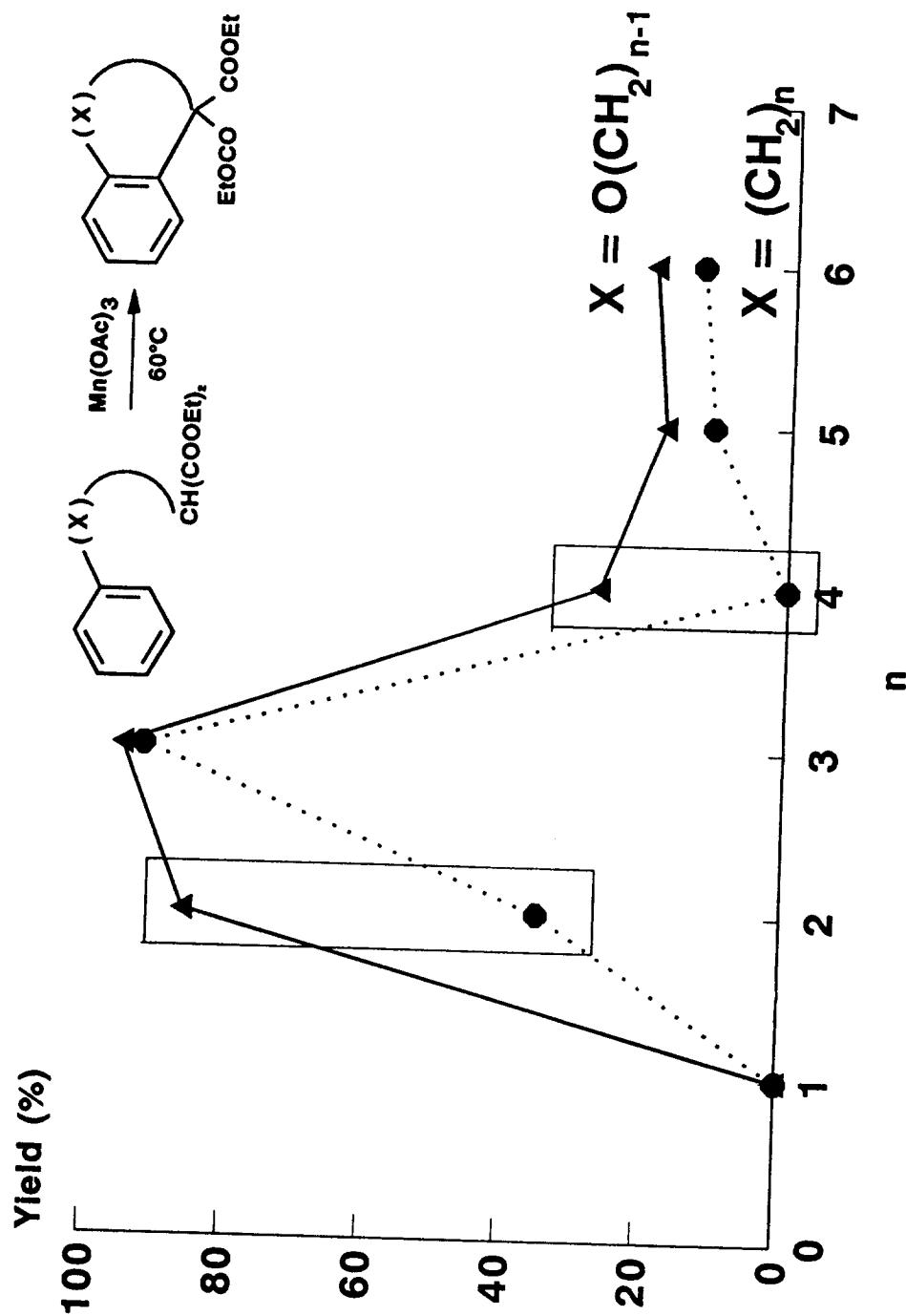


REACTIVITY OF MALONYL RADICALS

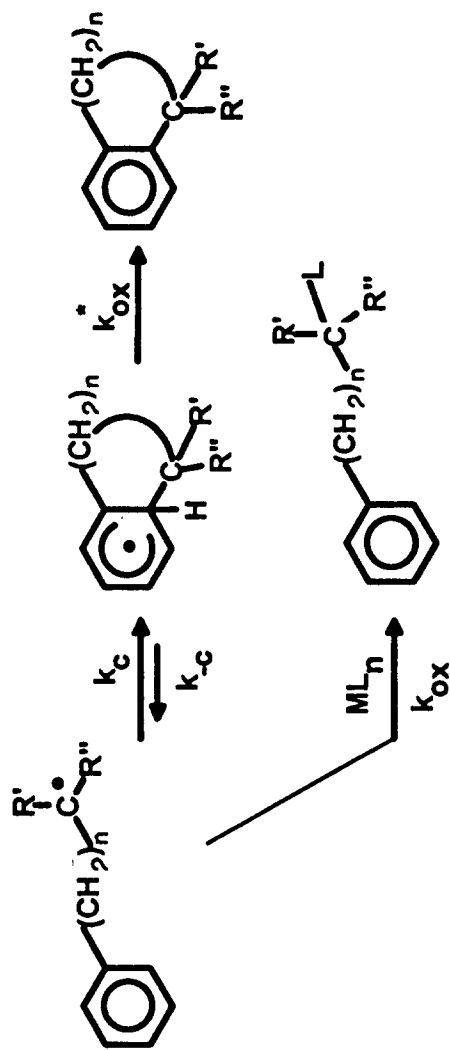




Intramolecular aromatic malonylation by Mn(III) acetate of ω -aryloxyalkylmalonates and ω -aryloxyalkylmalonates.



EFFECTS OF SUBSTITUENTS AND RING SIZE



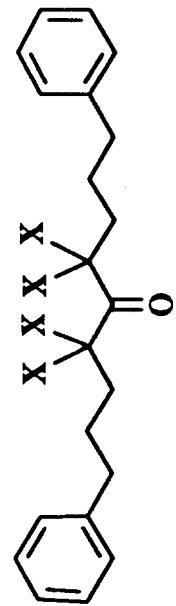
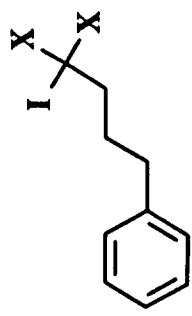
k_c ($M^{-1}s^{-1}$)

n	R=R'=H*	R=H, R'=CN**	R=R'=COOEt***
2	< 10 ²	10 ² -10 ³	-
3	3 x 10 ²	4 x 10 ³	2 x 10 ³
4	3 x 10 ³	1.3 x 10 ⁴	6.4 x 10 ⁴
5	1 x 10 ²	3 x 10 ²	7 x 10 ²

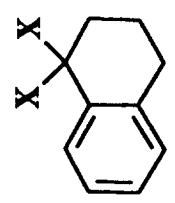
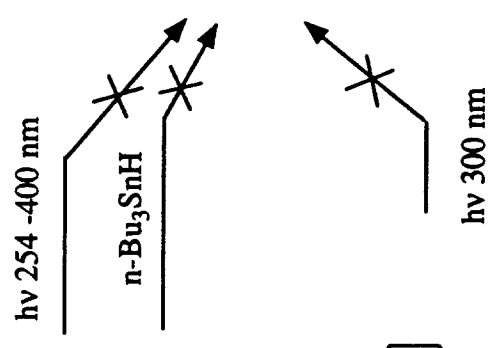
* $k_{ox} = 2 \times 10^5 M^{-1}s^{-1}$ (L = OAc) at 298°C;

** $k_{ox} = 1.2 \times 10^7 M^{-1}s^{-1}$ (L = SCN) at 298 °C

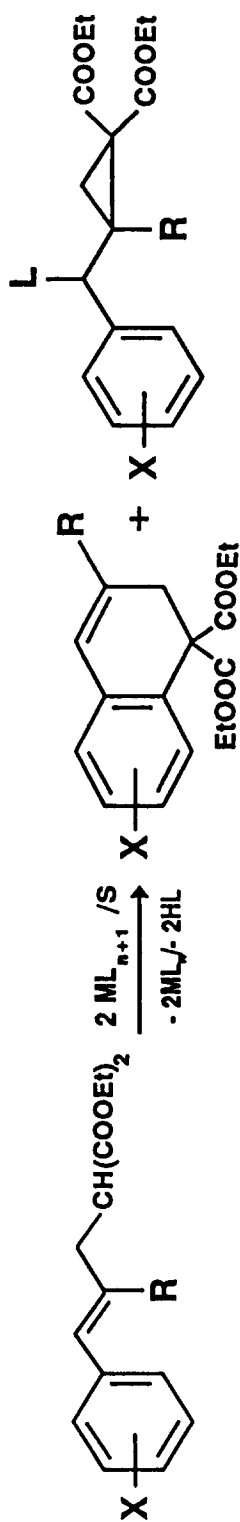
*** $k_a(\text{styrene}) = 8 \times 10^6 M^{-1}s^{-1}$



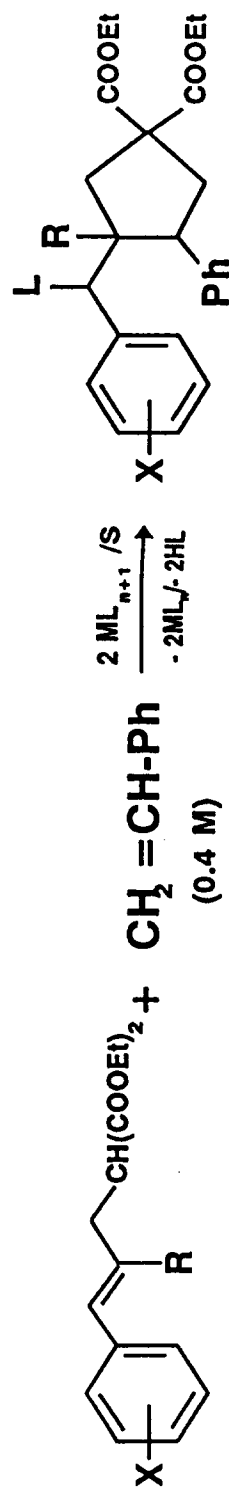
X = COOEt



Oxidation of diethyl 3-phenyl-2-propenylmalonates by Mn(III) acetate
in AcOH at 60°C and Fe(III) perchlorate in AN at 20°C.

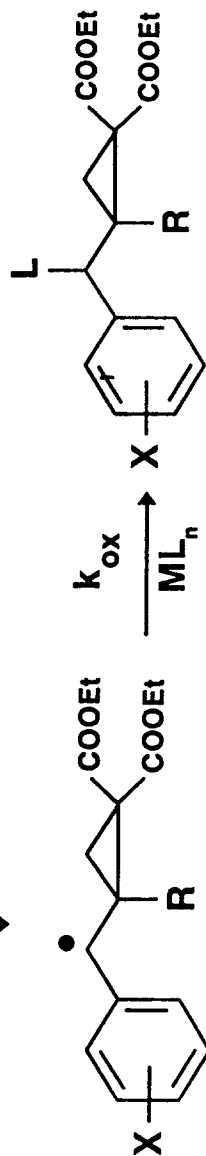
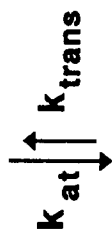
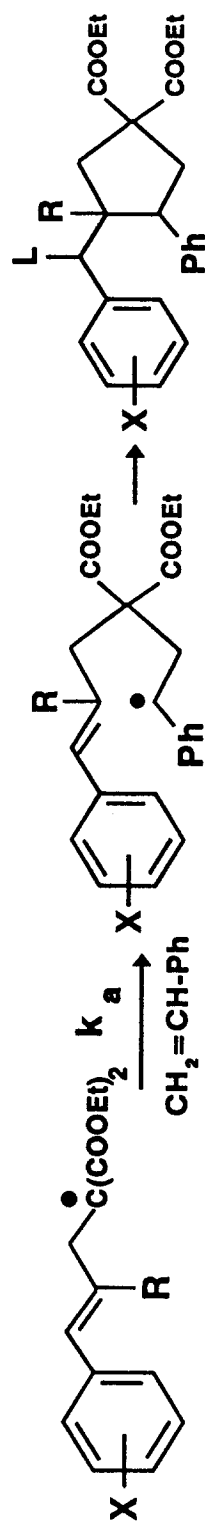


Mn(III)/AcOH	X = H; R = H	68	B	20
Mn(III)/AcOH	X = H; R = Me	86		3
Fe(III)/AN	X = H; R = Me	34		43



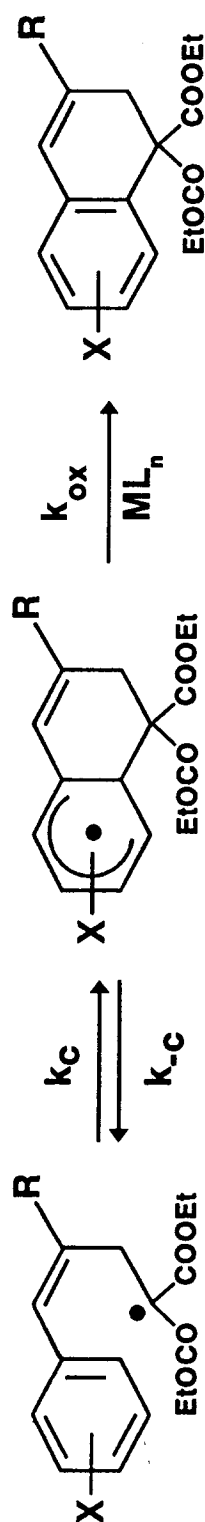
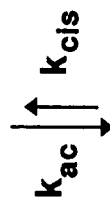
Mn(III)/AcOH	X = H; R = H	83
Mn(III)/AcOH	X = H; R = Me	78

COMPETITIVE RADICAL PROCESSES IN THE OXIDATION OF CINNAMYL MALONATE

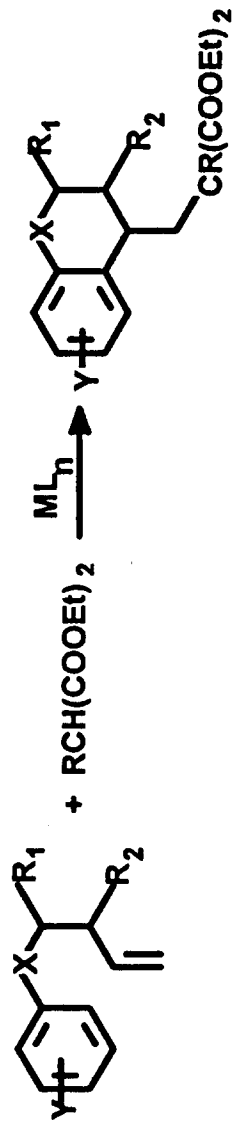


$k_a/k_c = 7.3$

$k_c = 1.1 \times 10^6 \text{ M}^{-1} \text{ s}^{-1}$



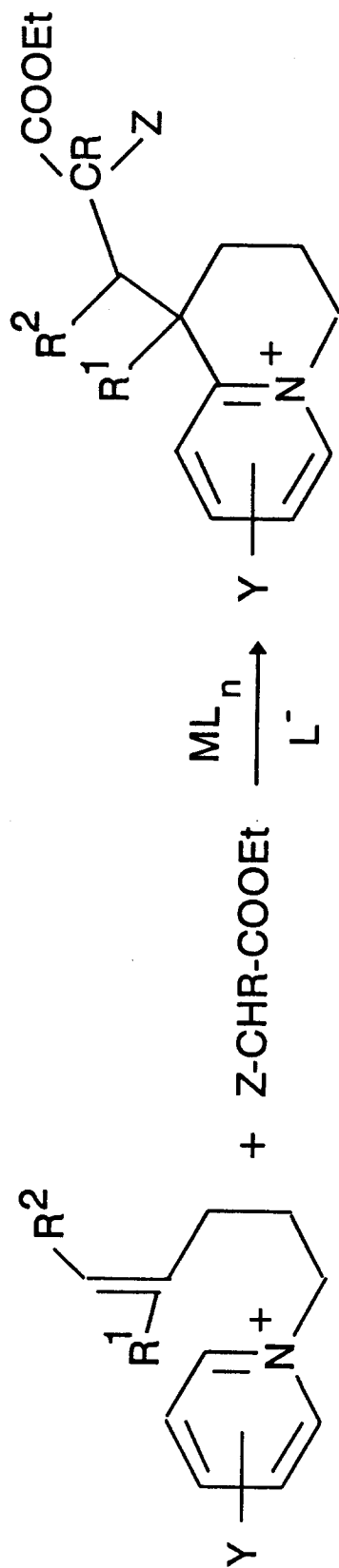
INTERMOLECULAR ADDITION TO OLEFINS (A)



X	Y	R1	R2	R	Yield %
CH2	H	H	H	Me	54*
O	H	H	H	Me	72*
CH2	3,5-di COOEt	H	H	Me	88
-	3-OBu ^t	H	H	Me	72*
NHAc	H	CN	OAc	Me	84*
NHAc	3,5-di Cl	H	H	COOEt	61

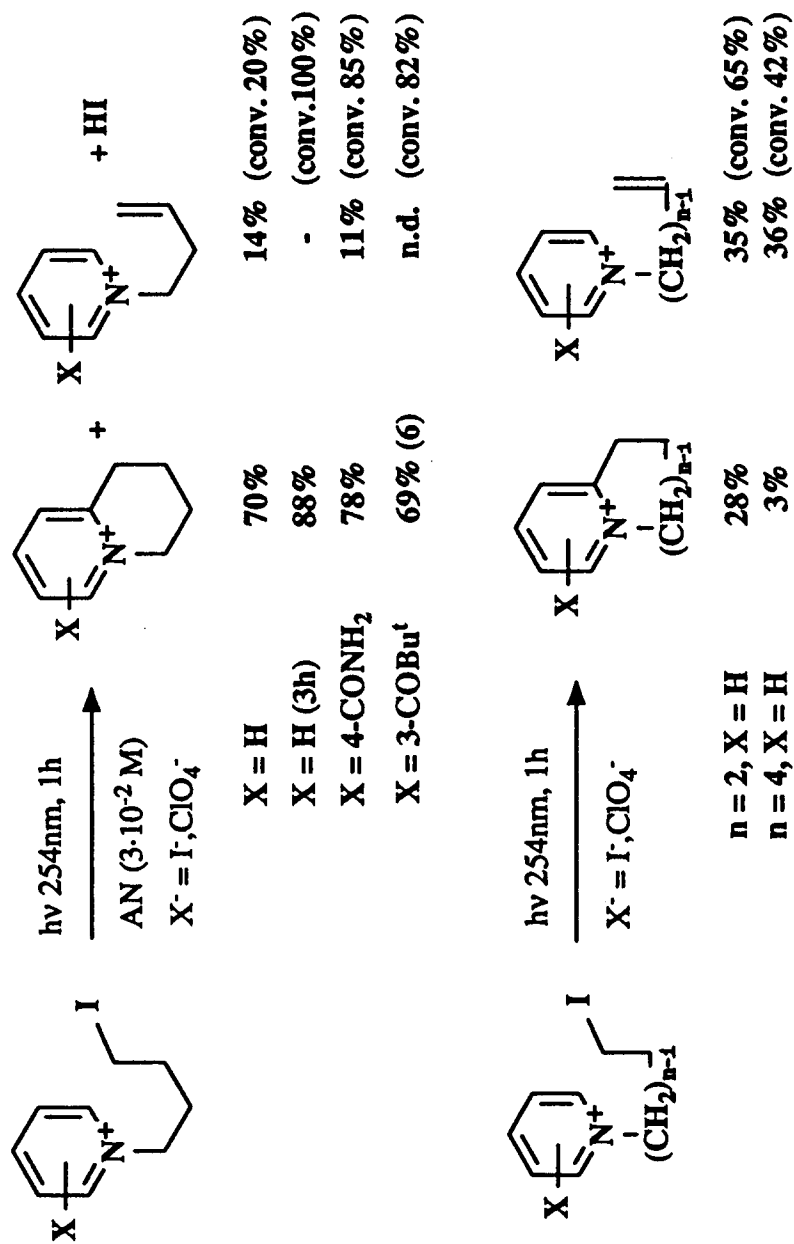
* Inverse addition

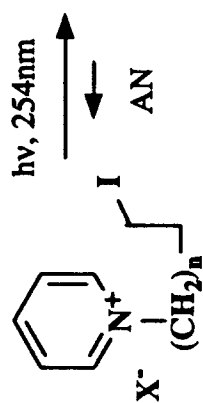
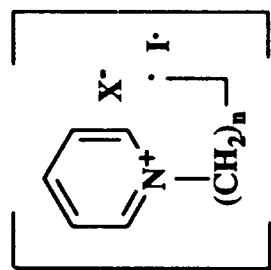
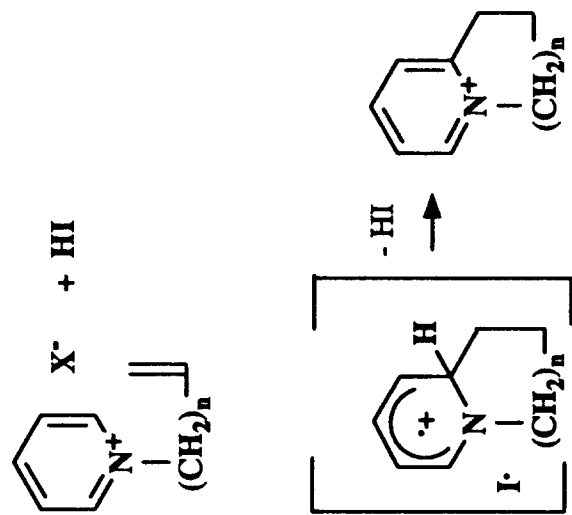
**OXIDATIVE ADDITION-CYCLIZATION OF CARBONYL COMPOUNDS
TO N-(4-PENTENYL)-PYRIDINIUM SALTS**



$\text{Mn}(\text{OAc})_3 / \text{AcOH} / 60^\circ\text{C}, 4\text{h}$	$\text{Z} = \text{COOEt}, \text{R} = \text{H}$	81%
$\text{Mn}(\text{OAc})_3 / \text{AcOH} / 60^\circ\text{C}, 4\text{h}$	$\text{Z} = \text{COOEt}, \text{R} = \text{Me}$	85%
$\text{Mn}(\text{OAc})_3 / \text{AcOH} / 60^\circ\text{C}, 4\text{h}$	$\text{Z} = \text{CN}, \text{R} = \text{Me}$	72%
$\text{Fe}(\text{ClO}_4)_3 \cdot 6 \text{H}_2\text{O} / \text{AN} / \text{Ac}_2\text{O} / 15^\circ\text{C}, 2\text{h}$	$\text{Z} = \text{COOEt}, \text{R} = \text{Me}$	74%
$\text{FeCl}_3 / \text{AN} / 30^\circ\text{C} / 4\text{h}$	$\text{Z} = \text{COOEt}, \text{R} = \text{Me}$	43%

$$\text{R}^1 = \text{R}^2 = \text{Y} = \text{H} \quad k_c > 10^7 \text{M}^{-1} \text{s}^{-1} \quad (60^\circ\text{C})$$

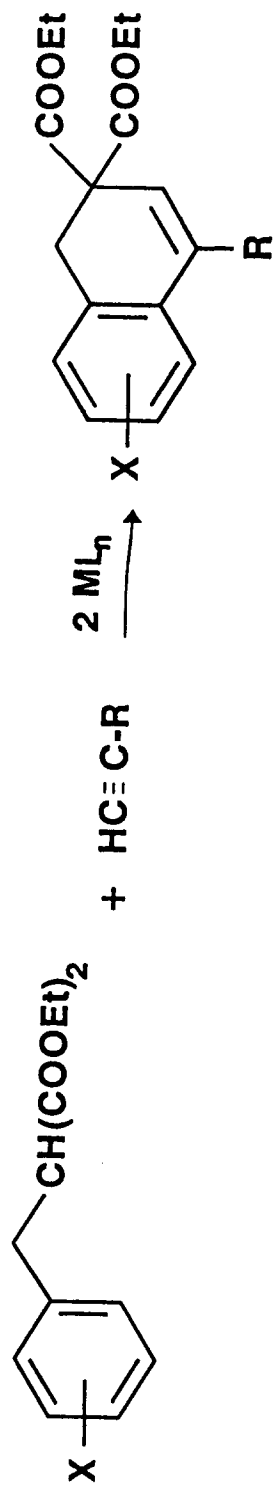
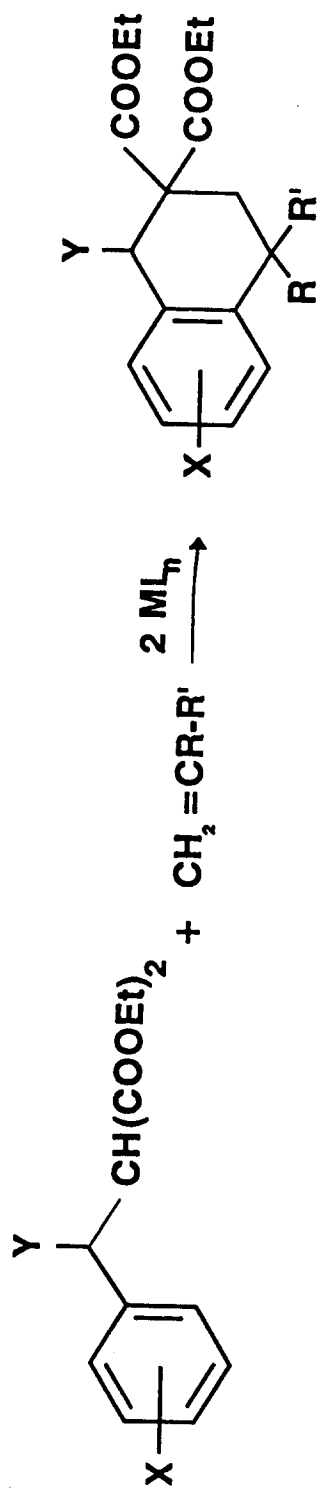




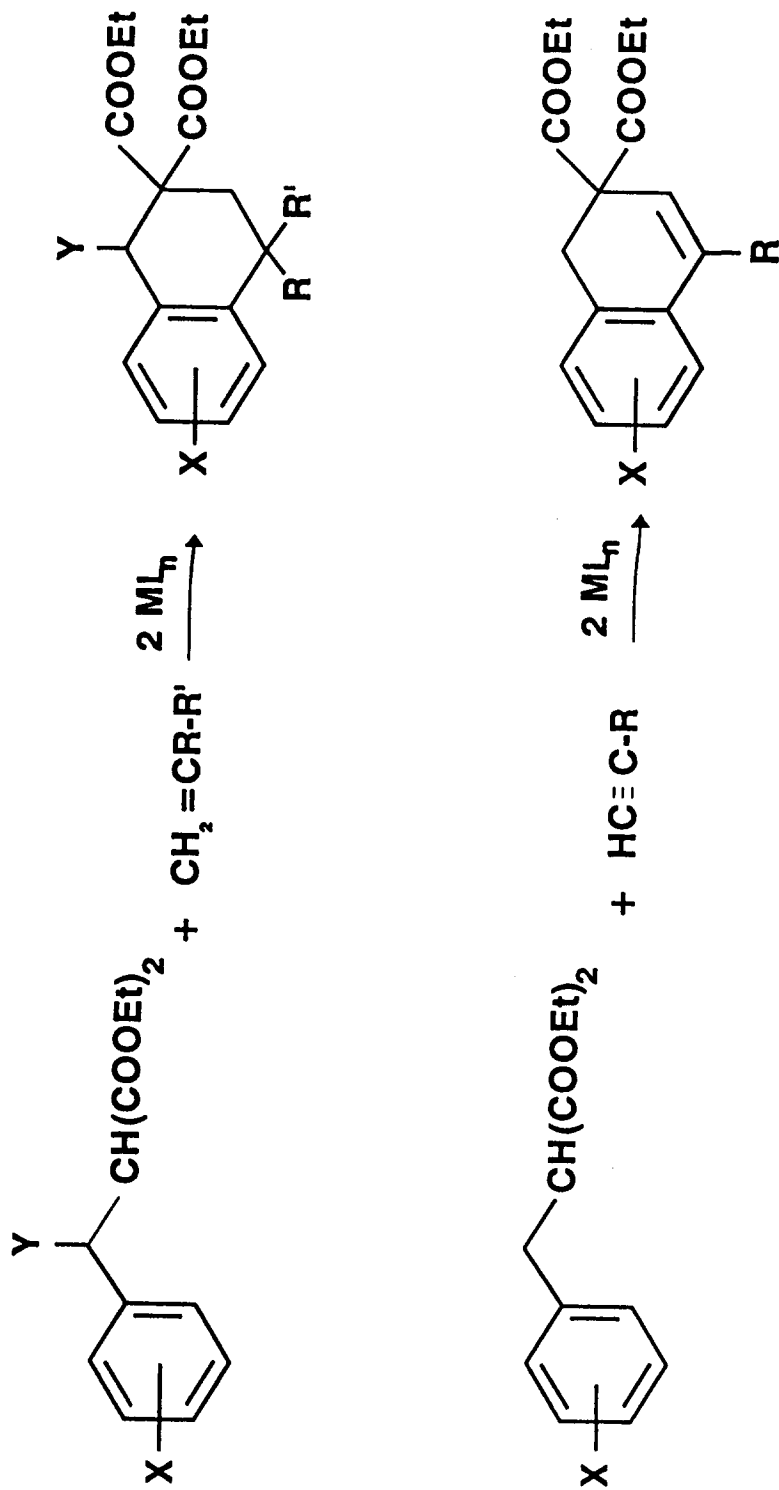
n	k_c/k_H
1	0.8
2	4.3
3	0.1

$k_c = 6.7 \cdot 10^7 \text{ M}^{-1} \text{ s}^{-1} (25^\circ \text{C}) [k_H \text{ Bu}_3\text{SnH}]$

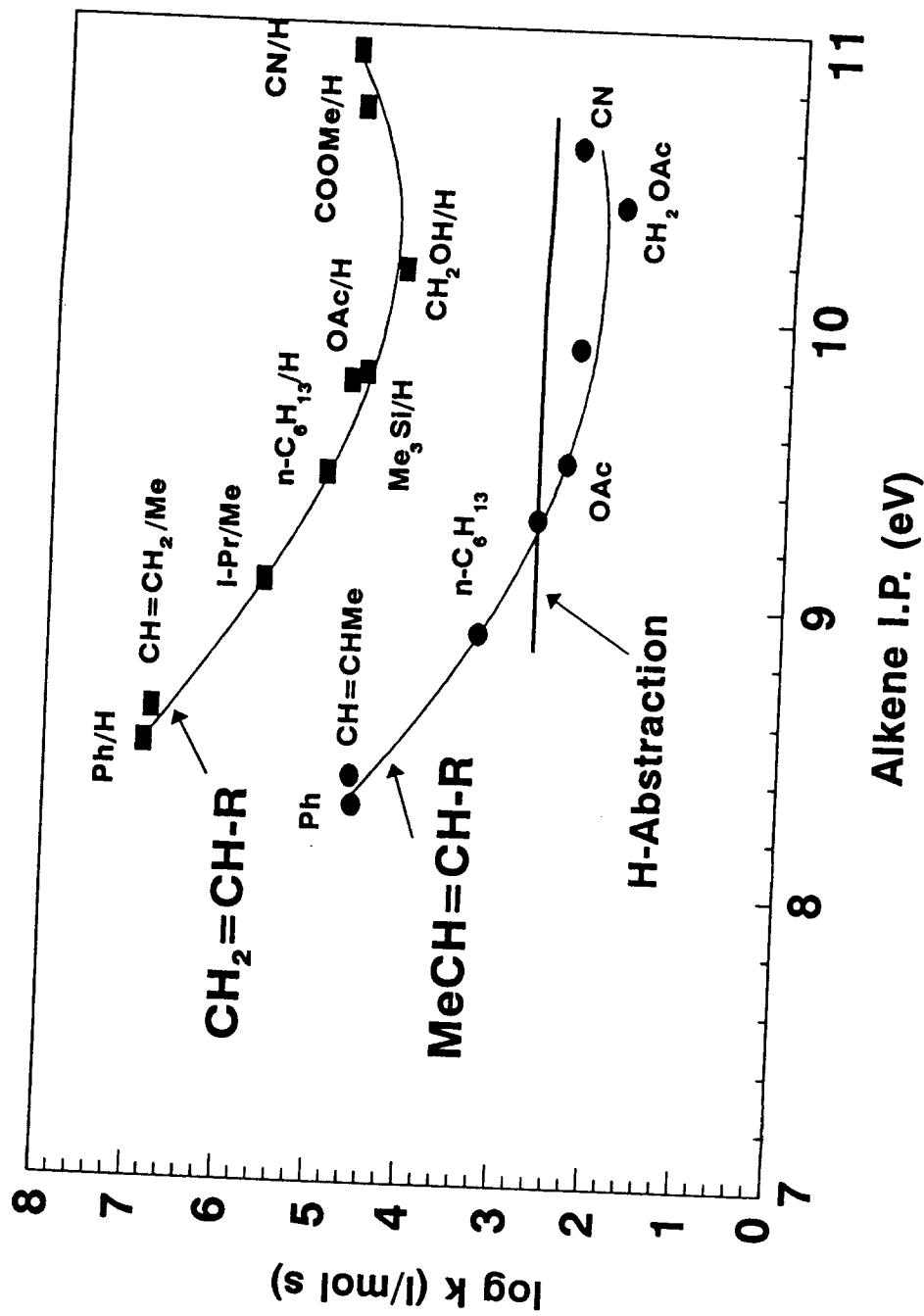
OXIDATIVE ADDITION-CYCLIZATION OF DIALKYL BENZYL MALONATES TO ALKENES AND ALKYNES INDUCED BY HIGH VALENT METAL SALTS.



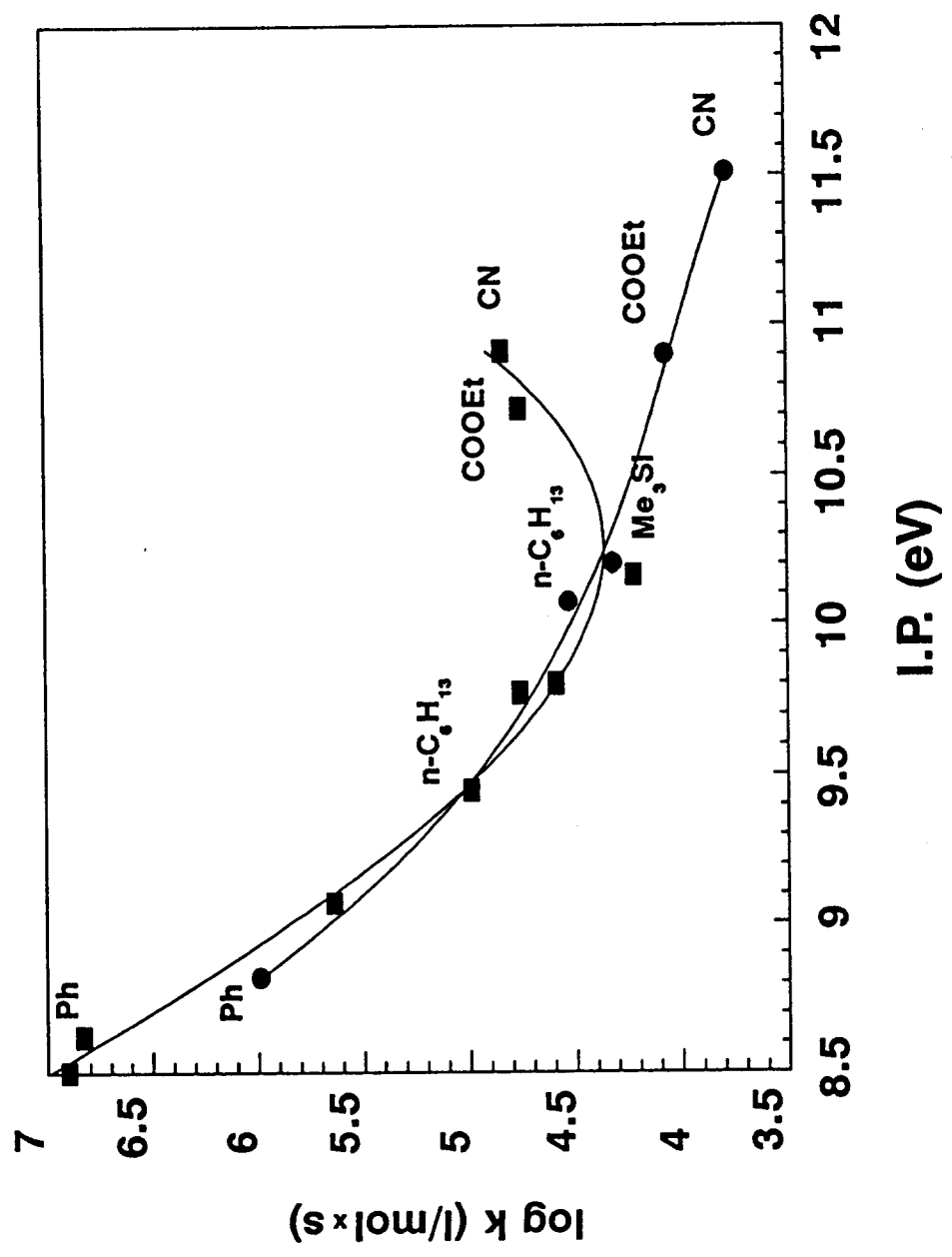
OXIDATIVE ADDITION-CYCLIZATION OF DIALKYL BENZYL MALONATES TO ALKENES AND ALKYNES INDUCED BY HIGH VALENT METAL SALTS.

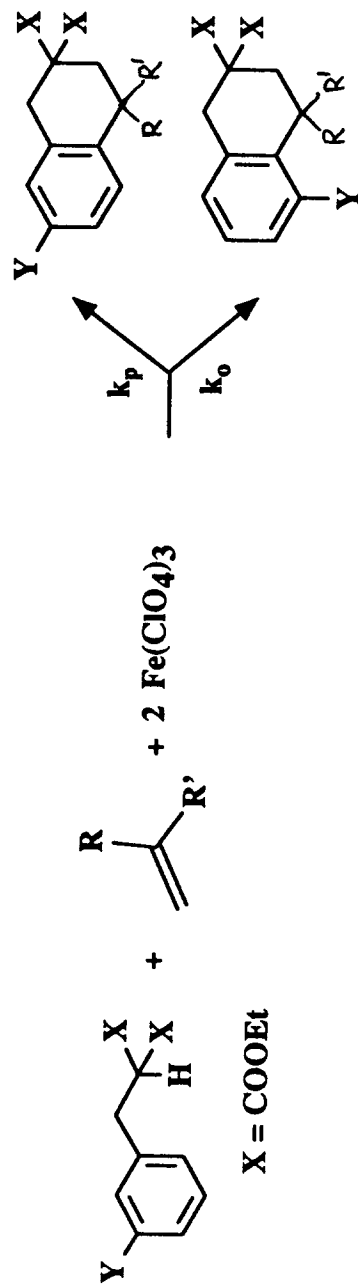


Dependence of Absolute Rate Constants of Addition of Diethyl Benzy/malonyl Radicals (log k) on the Ionization Potential of 1,1- and 1,2-Disubstituted Alkenes.



Dependence of the absolute rate constants of benzylmalonyl radical addition (log k) on the ionization potential of alkenes (■) and alkynes (●).





$R = \text{H}, R' = n\text{-C}_6\text{H}_{13}$

$$\log k_p = 1.07 \sigma_p + 0.11 \quad (r = 0.9978)$$

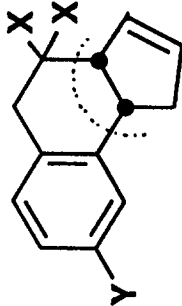
$$\log k_o = 1.23 E_s + 0.8 \sigma_o + 0.16 \quad (r = 0.9763)$$

$R = R' = \text{COOEt}$

$$\log k_p = -1.52 \sigma_p + 0.20 \quad (r = 0.9889)$$

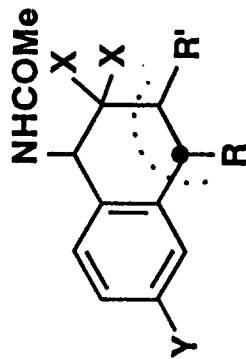
$$\log k_o = 1.78 E_s - 1.4 \sigma_o + 0.10 \quad (r = 0.9876)$$

FUNCTIONAL GROUPS COMPATIBILITY IN THE OXIDATIVE ADDITION-CYCLIZATION OF DIETHYL ARYL METHYLMALONATE TO ALKENES INDUCED BY Mn(III)ACETATE.



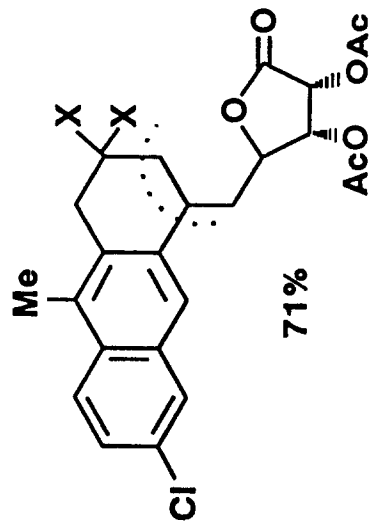
Y=H 55%

Y=NO₂ 73%

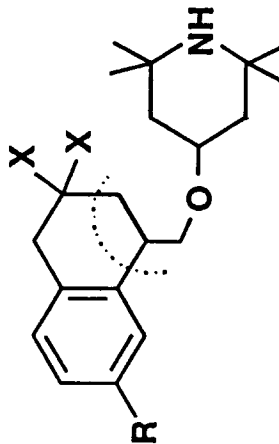


Y=R'=H, R=COOEt 68%

Y=CN, R=R'=COOEt 42%

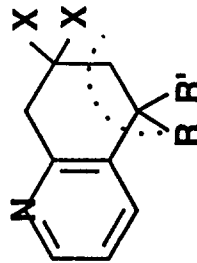


71%



R=H 93%

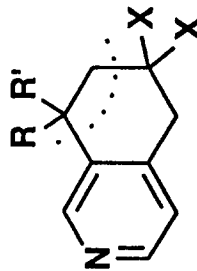
R=SOME 76%



R=H, R'=Ph 66%

R=Me, R'=Ph 21%

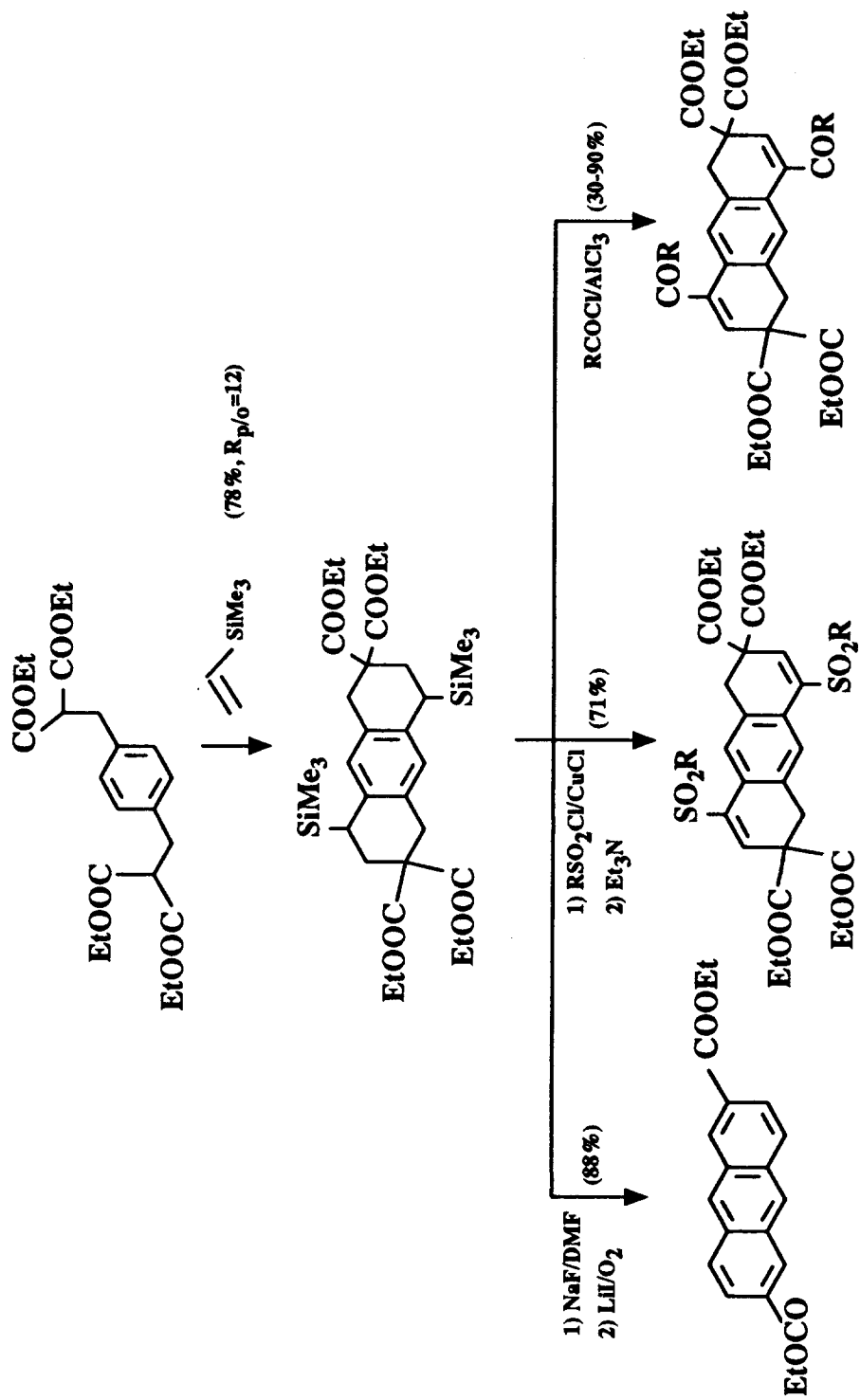
R=H, R'=OAc 72%



R=Me, R'=n-Bu 67%

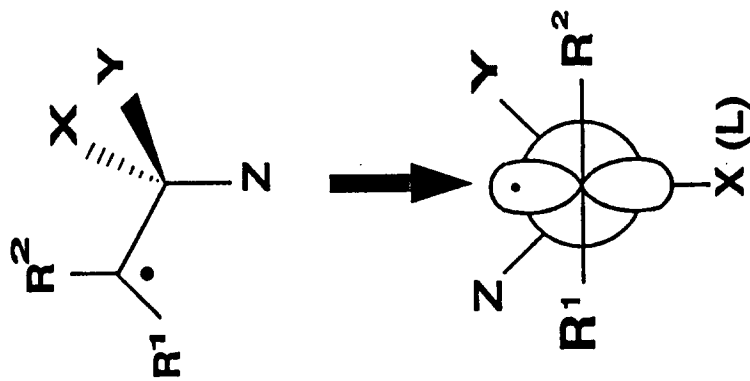
R=H, R'=CH₂CH₂-Ph 59%

R=H, R'=COOEt 31%

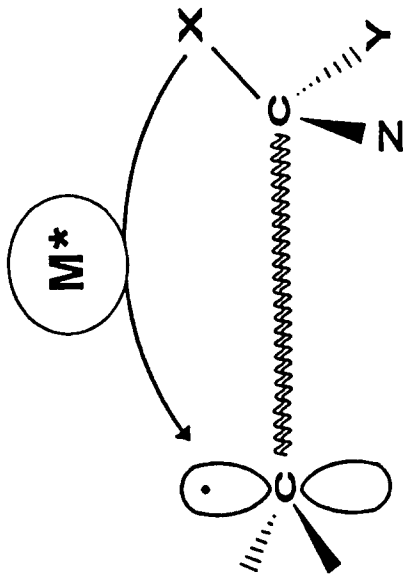


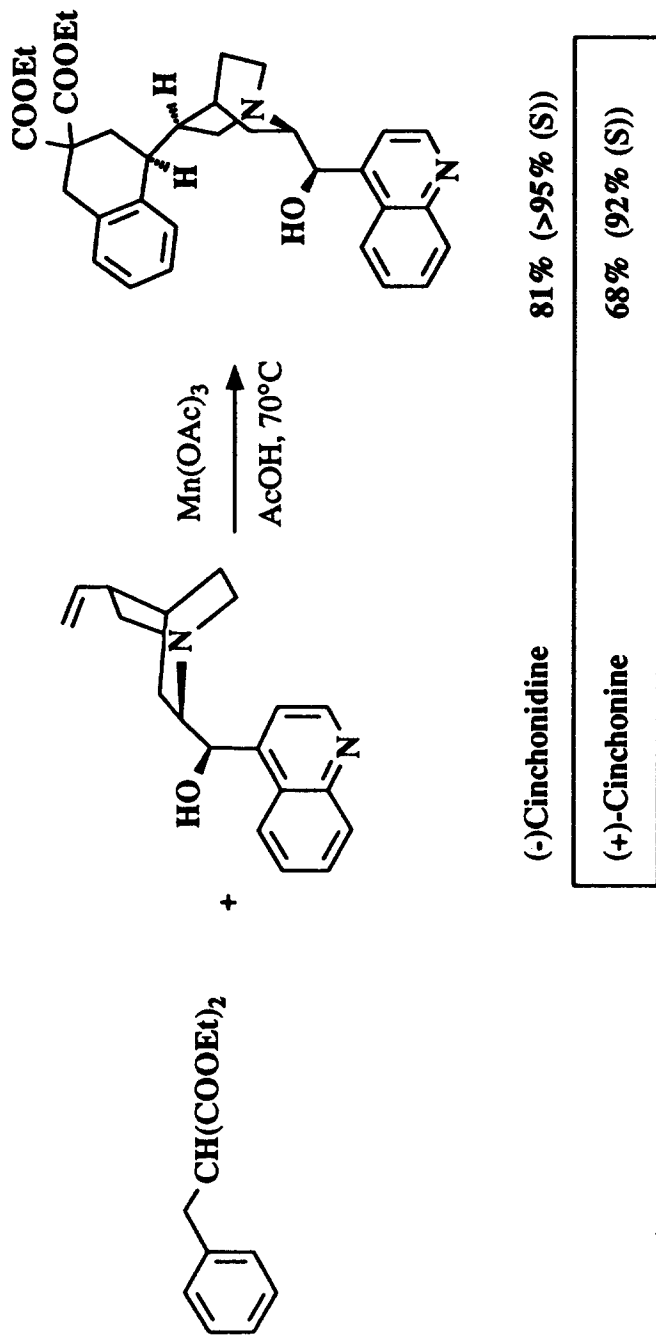
ASYMMETRIC INDUCTION

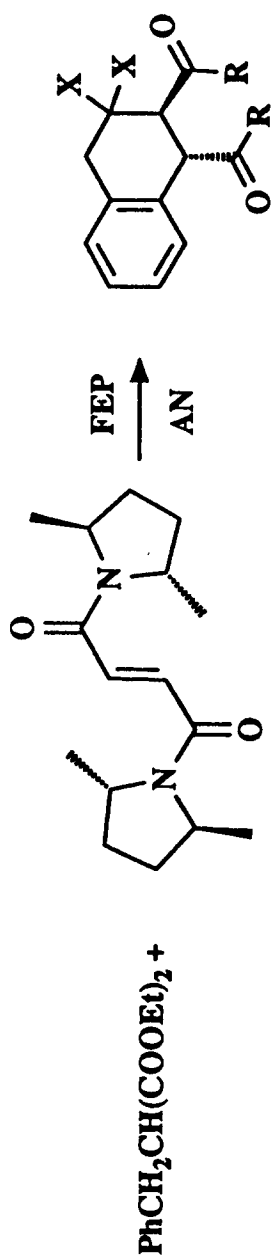
1,2-INDUCTION



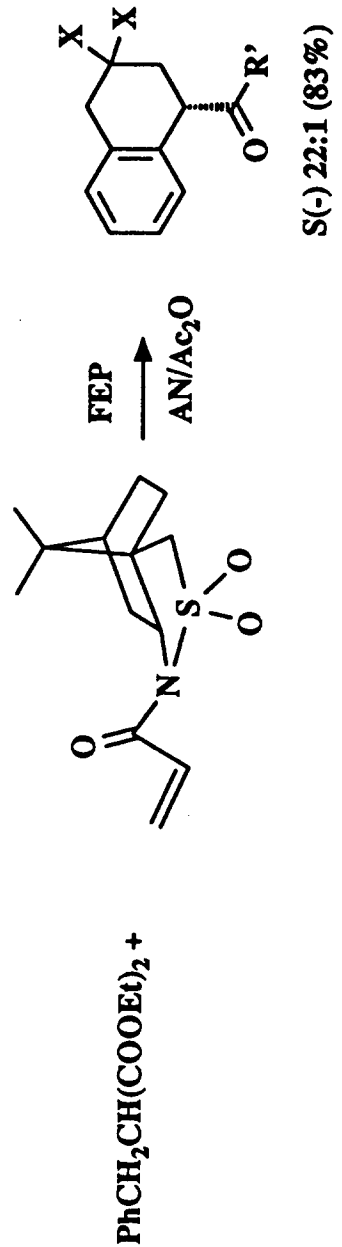
1,n-INDUCTION







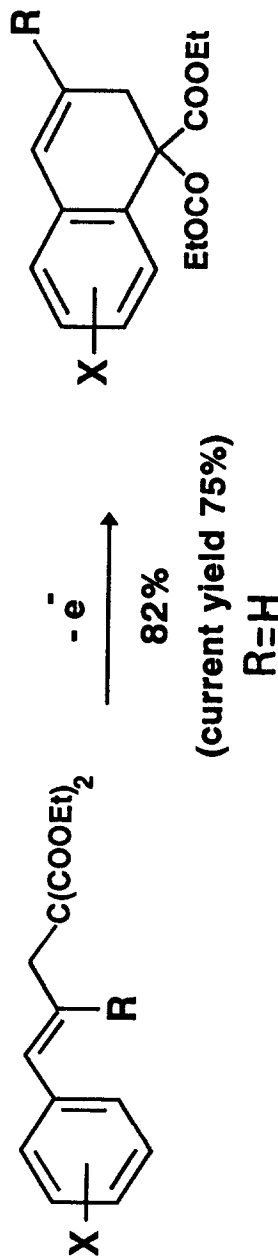
$S,S\text{-}(+) (68\%)$



$S(-) 22:1 (83\%)$

Electrochemical Production of Mn(III) Acetate (in-cell process)

ELECTROLYSIS : Anode = Carbon rod $[\text{Mn}(\text{OAc})_3] = 0.03 \text{ M}$
Cathode = Zirconium $[\text{KOAc}] = 1 \text{ M}$
Solvent = AcOH/AN
Temperature = 60-90°C
d.d.p. = 3.6 V
Curr. dens. = 120 mA/cm²



OXIDATIVE CYCLIZATION OF MALONIC ESTERS BY ELECTROCHEMICALLY GENERATED Mn(III) ACETATE.

